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RELATIVE ABUNDANCE OF ADULTS OF *CALLIRHOPALUS BIFASCIATUS* (ROELOFS) AND THREE *OTIORHYNCHUS* SPP. (COLEOPTERA: CURCULIONIDAE) ON CERTAIN CULTIVATED AND WILD PLANTS IN CONNECTICUT

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Abstract.—Adult weevils infesting cultivated and wild plants were sampled by dislodging them from foliage and by trapping them in pit-falls or under boards at six sites in Connecticut. The black vine weevil, *Otiorhynchus sulcatus* (F.), comprised 79–95% of the samples obtained by the three methods during June and July 1983. Less abundant species, which were concentrated on unsprayed plants, were: the strawberry root weevil, *O. ovatus* (L.); the rough strawberry root weevil, *O. rugosostriatus* (Goeze); and the twobanded Japanese weevil, *Callirhopalus bifasciatus* (Roelofs). *Otiorhynchus sulcatus* was the most abundant weevil on foliage of 71% of hosts surveyed in June and on 86% in July. Collectively, the results indicate that adults of *O. sulcatus* cause most of the foliar notching attributed to weevils. Possible wild reservoirs for *O. sulcatus* are given, and 17 new hosts for the four weevils are listed. Removal of adult hosts from field borders may minimize the establishment of wild reservoirs.

Shipment of nursery plants has increased the range of several exotic, flightless weevils (e.g., Maier, 1978). Even though nursery inspectors diligently search shipments for pestiferous weevils, they have little chance of detecting them if infestations consist of only a few adults in plant debris or a few eggs and larvae buried in the soil. In the absence of effective insecticides, undetected weevils, e.g., *Otiorhynchus* spp., can easily reach reproductive age because their host plants furnish food in the form of roots for larvae and foliage for adults. Infestations can be started by one or a few adults because many species are parthenogenetic and highly fecund (Smith, 1932; Maier, 1981, 1983b; Nielsen and Dunlap, 1981).

Recent increases in transcontinental shipping and interception of infested plants have caused Connecticut nursery inspectors to be concerned about what new weevils might be established in the state and what species are injuring nursery plants. The presence of new weevils may be difficult to detect because their foliar damage and larval appearance are likely to resemble those of the widespread black vine weevil, *Otiorhynchus sulcatus* (F.). Typically, after nurserymen or homeowners discover foliar notching, they make insecticide applications timed to control adults of *O. sulcatus.* No quantitative study exists to demonstrate if this weevil causes most of the injury or if spraying for it kills other weevils before they reproduce. This survey was undertaken to determine the identity and relative abundance of adult weevils that attack certain cultivated and nearby wild plants.

MATERIALS AND METHODS

Sampling for adults. Six Connecticut sites where weevils damaged plants in 1982 were sampled during June and/or July 1983. At each site, five pit-fall traps and five trap-boards (Maier, 1983a) were placed singly under different plants of each species sampled. The pit-fall traps, wax-coated cardboard cups measuring 11 cm across the circular top, were filled to about one-third of their depth with 200 ml of anhydrous isopropyl alcohol. Weevils that rested under boards during the day or that fell into pit-falls were collected twice weekly during two 2-week sampling periods: June 16 to 29 and July 16 to 29. In addition, on one night between June 16 and 23 and one between July 16 and 23, adults were dislodged from plants with a firm forehand blow and collected on a drop cloth. On each sampling occasion, 10 to 12 plant species per site were jarred for a total of 5 min/species between 2000 and 2200 hr EST when adults feed. Whenever possible, weevils were observed to confirm that they actually ate the foliage of plants upon which they rested. The Orange site (Table 1) was not sampled during June.

Weevils were identified by comparing them to published descriptions (e.g., Warner and Negley, 1976) and to a reference collection of known nursery pests: the twobanded Japanese weevil, *Callirhopalus bifasciatus* (Roelofs); the woods weevil, *Nemocestes* sp.; the strawberry root weevil, *Otiorhynchus ovatus* (L.); the rough strawberry root weevil, *O. rugosostriatus* (Goeze); the black vine weevil, *O. sulcatus*; and the obscure root weevil, *Sciopithes obscurus* Horn. Only weevils observed to eat leaves of cultivated plants were included in the analyses. This criterion excluded numerous billbugs, *Sphenophorus* spp., captured in pit-falls and two unidentified weevils captured on wild plants. Voucher specimens of the four species analyzed are deposited in the insect collection at The Connecticut Agricultural Experiment Station, New Haven.

Sampling sites. In Guilford, perennial ornamental plants, ranging in age from 2 to 10 years, were growing near the foundation of a house situated in a rural area. Hedgerows of *Forsythia* sp. and *Rosa multiflora* Thunb. were located about 10 m away. Both pit-falls and trap-boards were deployed under *Forsythia* sp., *Rhododendron* spp., *R. multiflora,* and *Taxus cuspidata* Sieb. and Zucc. No pesticides were applied between 1980 and 1983.

The site in New Haven was a large yard around a complex of buildings in a residential area. A more complete description is given by Maier (1978). Trapping devices were placed under *Cornus florida* L., *Ilex glabra* (L.) Gray, *Kalmia latifolia* L., *Pieris japonica* L., *Rhododendron* sp., and *T. cuspidata.* These plants, all at least 6 years old, were not sprayed with insecticides during the study. Only cultivated plants were sampled at New Haven and at Guilford.

Samples at Hamden were collected from a 4-year-old nursery and from wild plants within 50 m. Traps were distributed among *I. glabra, K. latifolia,* and *T. cuspidata* in the nursery and *R. multiflora* in the adjacent weedy field. During the 4 years of its existence, the nursery was not sprayed with pesticides.

The Orange site was a section of a commercial nursery. Many plants of *Rubus allegheniensis* Porter and other weedy species grew between the rows of ornamental plants. Sampling devices were deployed under *I. glabra, K. latifolia, Rhododendron* sp., and *T. cuspidata* in the rows and under *R. allegheniensis* between the rows. Two applications of acephate were made to the ornamental plants during 1983.

In Madison, sampling was conducted on nursery plants grown in containers, on shrubs grown for aesthetic purposes, and on wild plants situated around the container-grown ornamentals. Traps were placed along an embankment covered with *Cotoneaster dammeri* Schneid., under a hedgerow of *Chamaecyparis obtusa* (Sieb. and Zucc.), and under wild plants of *Berberis thunbergii* DC., *K. latifolia,* and *R. allegheniensis.* During summer 1983, acephate was applied at least twice to the container-grown stock and to *C. dammeri* and *C. obtusa.* The hedge of *C. obtusa* was not sprayed until June sampling was completed.

The location in Meriden was a nursery field surrounded by many species of wild plants growing along fencerows or in deciduous woods. Traps were placed under *P. japonica, Rhododendron* spp., and *T. cuspidata* in the commercial nursery and under wild *Celastrus scandens* L., *Cornus racemosa* Lam., and *R. multiflora* at the border of the forest. Ornamental plants grown for sale were sprayed three times with acephate during 1983. In addition, the area between rows of nursery plants was cultivated monthly during late spring and summer.

RESULTS

Among the weevils detected, *O. sulcatus* had the highest relative abundance in 32 (97%) of 33 collections obtained by the three sampling methods during June and July (Table 1). Adults of *O. sulcatus* represented 86% (range: 76–100%) and 80% (33–100%) of weevils captured on plants during June and July, respectively. This species comprised 92% (86–100%) and 79% (49–100%) of those in pit-falls and 95% (80–100%) and 94% (67–100%) of those under trap-boards during these respective months. Although the relative abundance of all species varied among sites and between months, *C. bifasciatus, O. ovatus,* and *O. rugosostriatus* usually represented only a small portion of each sample.

Otiorhynchus sulcatus occurred at all six sites, and *C. bifasciatus, O. ovatus,* and *O. rugosostriatus* at three (50%) each (Table 1). Overall, 95% of *C. bifasciatus* (N = 109), 100% of *O. ovatus* (N = 56) and *O. rugosostriatus* (N = 24), and 82% of *O. sulcatus* adults (N = 1,277) were collected on or under unsprayed plants. The three less widespread and less abundant weevils were associated mainly with unsprayed cultivated or wild plants at Guilford, New Haven, Hamden, and Madison although five (63%) of eight adults of *C. bifasciatus* from Orange were captured on or near sprayed plants.

All sampling techniques were successful for detecting *O. ovatus, O. rugosostriatus,* and *O. sulcatus* (Table 1). Trap-boards were least effective because they were not used as shelters by adults of *C. bifasciatus,* which remain on plants during the day. Of 1,416 weevils collected, trap-boards accounted for only 275 (19%), whereas dislodging and trapping with pit-falls yielded 692 (49%) and 449 (32%), respectively.

Otiorhynchus sulcatus was the most abundant of the four species in samples from 15 (71%) of 21 plant species that had weevils in June and from 18 (86%) of 21 that had them in July (Table 2). In June, *C. bifasciatus* dominated on four plants (19%), and *O. ovatus* on one (5%). In July, *O. ovatus* and *O. rugosostriatus* each represented the largest portion of adults dislodged from one (5%) plant species. During each sampling period, *O. sulcatus* and *O. rugosostriatus* were codominant on one cultivated species.

In the combined samples from June and July, *O. sulcatus* occurred on 22 (96%)

Table 1. Relative abundance (represented as % of total) of four weevil species captured by three methods at six Connecticut sites during June and/or July 1983.[a]

Location of sample	Month of sample	% of total represented by each species in samples obtained by:										
		Dislodging from plants				Trapping with pit-falls				Trapping with boards		
		C.b.	*O.o.*	*O.r.*	*O.s.*	*C.b.*	*O.o.*	*O.r.*	*O.s.*	*O.o.*	*O.r.*	*O.s.*
Guilford	June			21 (8)	79 (31)		11 (1)		89 (8)		20 (2)	80 (8)
	July			19 (5)	81 (22)			17 (1)	83 (5)			100 (8)
New Haven	June	14 (12)	1 (1)		85 (72)	12 (11)	1 (1)	1 (1)	86 (81)	4 (1)		96 (22)
	July	4 (6)	2 (3)	1 (2)	93 (138)	14 (11)	34 (27)	3 (2)	49 (39)	4 (3)	2 (2)	94 (77)
Hamden	June	24 (41)			76 (127)	3 (4)		1 (1)	96 (134)			100 (94)
	July	19 (12)			81 (52)	22 (4)			78 (14)			100 (24)
Orange	June											
	July	9 (5)			91 (49)	9 (3)			91 (28)			100 (17)
Madison	June		9 (2)		91 (21)		11 (2)		89 (17)			100 (2)
	July		67 (8)		33 (4)		28 (5)		72 (13)	33 (2)		67 (4)
Meriden	June				100 (26)				100 (8)			100 (2)
	July				100 (45)				100 (28)			100 (7)
Mean[b]	June	8	2	4	86	3	5	<1	92	1	4	95
	July	5	12	3	80	8	10	3	79	6	<1	94

[a] Abbreviations for weevil species are: *C.b.* = *Callirhopalus bifasciatus*; *O.o.* = *Otiorhynchus ovatus*; *O.r.* = *O. rugosostriatus*; and *O.s.* = *O. sulcatus*. Number of weevils is given in parentheses. Percentages are rounded to nearest whole number; values nearer to 0 than 1 are given as <1.

[b] Mean % represents the sum of each column divided by number of sites sampled (i.e., five in June and six in July).

Table 2. Relative abundance (represented as % of total) of weevils dislodged from cultivated and wild plants in Connecticut during June and/or July 1983.[a]

Identity of host plants		Sites where plants were sampled[b]
Family	Species	
Taxaceae	*Taxus cuspidata* Sieb. and Zucc.	G, N, H, O, Me
Cupressaceae	*Chamaecyparis obtusa* (Sieb. and Zucc.)	M
Ranunculaceae	*Paeonia* sp.	G
Berberidaceae	*Berberis thunbergii* DC.	H, M
Rosaceae	*Cotoneaster dammeri* Schneid.	M
	Rosa multiflora Thunb.	(G), H, Me
	Rosa sp.	G
	Rubus allegheniensis Porter	H, O, M
	R. occidentalis L.	H
Aquifoliaceae	*Ilex glabra* (L.) Gray	N, H, O
Celastraceae	*Celastrus scandens* L.	H, Me
Aceraceae	*Acer japonicum* Thunb.	M
Vitaceae	*Parthenocissus quinquefolia* (L.) Planch.	H, M
Cornaceae	*Cornus florida* L.	N, O
	C. racemosa Lam.	H, Me
Ericaceae	*Kalmia latifolia* L.	N, H, O, (M)
	Pieris japonica (Thunb.) D. Don	N, (Me)
	Rhododendron spp.	G, N, O, (Me)
	R. impeditum Bald. f. and W. W. Sm.	N
Polemoniaceae	*Phlox* sp.	G
Labiatae	*Monarda* sp.	N
Solanaceae	*Solanum dulcamara* L.	H
Caprifoliaceae	*Viburnum* sp.	O

[a] Abbreviations for weevil species are: *C.b.* = *Callirhopalus bifasciatus*; *O.o.* = *Otiorhynchus ovatus*; *O.r.* = *O. rugosostriatus*; and *O.s.* = *O. sulcatus*. Number collected on each plant species is given in parentheses; percentages are rounded to nearest whole number.

[b] Sites are abbreviated as follows: G = Guilford, N = New Haven, H = Hamden, O = Orange, M = Madison and Me = Meriden. An underlined abbreviation indicates that a plant grew in the wild at that site. An abbreviation enclosed in parentheses denotes that the plant was sampled at that site but that no weevils were collected. Orange was not sampled in June.

of 23 plant species, *C. bifasciatus* on eight (35%), and both *O. ovatus* and *O. rugosostriatus* on three (9%) each (Table 2). *Otiorhynchus sulcatus* was the lone species obtained from 10 (43%) plant species, and *C. bifasciatus* was the only weevil from one (4%).

When weevil abundance was standardized by dividing total captures per plant species listed in Table 2 by the number of sites sampled, the mean number of *O. sulcatus* on *T. cuspidata* (58.4), *C. florida* (32.0), and *Parthenocissus quinquefolia* (L.) Planch. (29.5) was more than 2× that on other species. Similarly, the average number of *C. bifasciatus* on *R. multiflora* (12.0) and *C. florida* (10.0) was higher than that on other hosts.

At Orange, Madison, and Meriden, adults of one or more weevil species were associated with wild hosts that grew near sprayed ornamental plants (Tables 1 and

Table 2. Continued.

% of total comprised by each weevil in June				% of total comprised by each weevil in July			
C.b.	*O.o.*	*O.r.*	*O.s.*	*C.b.*	*O.o.*	*O.r.*	*O.s.*
			100 (122)				100 (141)
			100 (15)				100 (1)
		50 (5)	50 (5)			67 (4)	33 (2)
	25 (1)		75 (3)		100 (4)		
			100 (4)				100 (2)
67 (29)			33 (14)	48 (11)			52 (12)
			100 (2)				100 (4)
	100 (1)			18 (2)	36 (4)		46 (5)
100 (3)							100 (1)
			100 (7)				100 (15)
29 (2)			71 (5)	33 (1)			67 (2)
			100 (2)				
			100 (50)				100 (9)
48 (10)			52 (11)	12 (5)			88 (37)
100 (4)							100 (11)
22 (2)			78 (7)	13 (4)			87 (26)
						33 (2)	67 (4)
			100 (13)				100 (18)
			100 (3)				100 (4)
		27 (3)	73 (8)			50 (1)	50 (1)
	14 (1)		86 (6)		20 (3)		80 (12)
100 (3)							
							100 (3)

2). In the combined samples from Orange (Table 1), three (38%) of eight *C. bifasciatus* and six (6%) of 94 *O. sulcatus* were captured on or under *R. allegheniensis* plants growing in the nursery. At Madison, 13 (68%) of 19 *O. ovatus* and two (3%) of 61 *O. sulcatus* were associated with *R. allegheniensis* plants established at the border of sprayed areas. Another five (26%) *O. ovatus* were taken near *B. thunbergii.* At Meriden, 18 (16%) of 116 *O. sulcatus* were associated with wild plants growing in brushy areas adjacent to sprayed fields. Sixteen of these were present in the combined samples from *C. racemosa* Lam. bushes located within 3–5 m of infested *T. cuspidata.* Captures of *O. sulcatus* on or under wild *C. racemosa* increased markedly from one in June to 15 in July, suggesting either that weevils had dispersed from the infested *T. cuspidata* to the nearby *C. racemosa,* or that adults had emerged near *C. racemosa* in July.

Feeding by each weevil species was confirmed for each possible host listed in Table 2 except for *Acer japonicum* Thunb. and *P. japonica.* New feeding hosts for adults are: *C. bifasciatus—R. allegheniensis, C. scandens, C. racemosa,* and *Solanum dulcamara* L.; *O. ovatus—B. thunbergii* and *Monarda* sp.; *O. rugosostriatus—Paeonia* sp. and *Phlox* sp.; *O. sulcatus—C. obtusa, Paeonia* sp., *B. thunbergii, C. dammeri, R. multiflora, P. quinquefolia, C. racemosa, Phlox* sp., and *Monarda* sp.

DISCUSSION

The four exotic weevils captured in Connecticut are widely recognized as plant pests in North America and in other regions of the world (e.g., Smith, 1932; Wilcox et al., 1934; Allen, 1957; Warner and Negley, 1976). In Connecticut, *O. sulcatus,* the most abundant species, is surely responsible for most of the leaf injury to sprayed and unsprayed ornamental plants. Its relatively high abundance on plants growing in yards and nurseries corroborates previous reports of it as a pest in Connecticut (Britton, 1914; Johnson, 1941). Infestations of *C. bifasciatus* and *O. ovatus* have also resulted in foliar or root damage in Connecticut (Britton, 1910, 1932). As shown in this survey, every one of the four weevils feeds upon foliage of unsprayed plants. The recovery of *C. bifasciatus* in Orange apparently represents the first record of this species in a commercial nursery in the United States. Insecticide applications timed for *O. sulcatus* may not be effective against *C. bifasciatus* because adults of the latter emerge one month earlier (Maier, 1981, 1983b).

Even though the four weevils are highly polyphagous (Smith, 1932; Warner and Negley, 1976; Marrone and Zepp, 1979), their reproductive potential varies markedly on different feeding hosts (Cram and Pearson, 1965; Maier, 1981, 1983b; Nielsen and Dunlap, 1981). The capability of adults to recognize and use superior over poor hosts may influence dispersion. However, the number of host plant records per species (Table 2) is probably correlated principally with abundance (i.e., an abundant weevil is more likely to be sampled than is a less abundant one), not with actual host range. Interestingly, *C. bifasciatus* attains higher relative abundance on *R. multiflora* and *C. florida* than it does on other hosts, indirectly supporting Maier's (1983b) contention that the first two are among the better hosts for nourishing the reproductive development of this weevil. Similarly, the high reproductive potential of *O. sulcatus* on *Taxus* spp. (Maier, 1981; Nielsen and Dunlap, 1981) may account partly for its high abundance on these plants.

Cram and Pearson (1965), Maier (1981), Nielsen and Dunlap (1981), and others have shown that adults of *O. sulcatus* can lay eggs in the laboratory when they feed exclusively on the foliage of certain wild plants. However, evidence for the existence of wild reservoirs is scant. Cram and Pearson (1965) have observed that adults feed on weeds in peat bogs and have suggested that weeds might facilitate population increases. Smith (1932) has listed larval and adult hosts of *O. sulcatus,* including plants that could grow in the wild, but did not indicate under what circumstances his observations were made. In this study, I have witnessed feeding on several wild plants; and at Hamden, adults have emerged from soil beneath caged wild *R. multiflora* (unpubl. data). At Meriden, *O. sulcatus* may have dispersed from *T. cuspidata* to *C. racemosa.* Should *C. racemosa* be used as a larval host, a second reservoir would be documented.

Chemical annihilation of populations of *O. sulcatus* in nursery fields at Hamden, Meriden, and elsewhere might not provide lasting control because adults could walk from nearby wild reservoirs to cultivated plants (Maier, 1978). Nielsen and Dunlap (1981) have similarly suggested dispersal from wild grape to cultivated plants, but they have not shown that weevils attack grape in the wild. Collectively, available evidence suggests that removal of possible wild hosts growing near field borders should lessen the chances of adults colonizing wild plants and reinfesting nursery fields.

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LITERATURE CITED

Allen, H. W. 1957. A Japanese weevil abundant in the Philadelphia area. Entomol. News 68: 169–174.

Britton, W. E. 1910. Strawberry crown girdler attacking young hemlocks. Connecticut Agric. Exp. Stn. (New Haven), 33rd and 34th Annu. Rept. 1909–1910:370–372.

Britton, W. E. 1914. *Taxus* plants in nursery injured by a weevil, *Otiorhynchus sulcatus* Fabr. Connecticut Agric. Exp. Stn. (New Haven), 37th Annu. Rept. 1913:230–232.

Britton, W. E. 1932. Injury by a Japanese weevil, *Pseudocneorrhinus setosus* Roelofs. J. Econ. Entomol. 25:931.

Cram, W. T. and W. D. Pearson. 1965. Fecundity of the black vine weevil, *Brachyrhinus sulcatus* (F.), fed on foliage of blueberry, cranberry, and weeds from peat bogs. Proc. Entomol. Soc. British Columbia 62:25–27.

Johnson, J. P. 1941. The black vine weevil and its control. Connecticut Agric. Exp. Stn. (New Haven) Bull. 445:367–370.

Maier, C. T. 1978. Dispersal of adults of the black vine weevil, *Otiorhynchus sulcatus* (Coleoptera: Curculionidae), in an urban area. Environ. Entomol. 7:854–857.

Maier, C. T. 1981. Reproductive success of the black vine weevil, *Otiorhynchus sulcatus* (F.), fed different foliar diets and evaluation of techniques for predicting fecundity. Environ. Entomol. 10:928–932.

Maier, C. T. 1983a. Use of trap-boards for detecting adults of the black vine weevil, *Otiorhynchus sulcatus* (Fabricius) (Coleoptera: Curculionidae). Proc. Entomol. Soc. Washington 85:374–376.

Maier, C. T. 1983b. Influence of host plants on the reproductive success of the parthenogenetic twobanded Japanese weevil, *Callirhopalus bifasciatus* (Roelofs) (Coleoptera: Curculionidae). Environ. Entomol. 12:1197–1203.

Marrone, P. G. and D. B. Zepp. 1979. Descriptions of the larva and pupa of *Callirhopalus* (subg. *Pseudocneorhinus*) *bifasciatus,* the twobanded Japanese weevil, with new host plant records. Ann. Entomol. Soc. Amer. 72:833–836.

Nielsen, D. G. and M. J. Dunlap. 1981. Black vine weevil: reproductive potential on selected plants. Ann. Entomol. Soc. Amer. 74:60–65.

Smith, F. F. 1932. Biology and control of the black vine weevil. U.S. Dep. Agric. Tech. Bull. 325:1–45.

Warner, R. E. and F. G. Negley. 1976. The genus *Otiorhynchus* in America North of Mexico. Proc. Entomol. Soc. Washington 78:240–262.

Wilcox, J., D. C. Mote and L. Childs. 1934. The root-weevils injurious to strawberries in Oregon. Oregon Agric. Exp. Stn. Bull. 330:1–109.

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